

CHAPTER 4

MAGNETIC TAPE RECORDER TRANSPORTS

LEARNING OBJECTIVES

After completing this chapter, you'll be able to do the following:

1. Describe the function and components of a basic magnetic tape transport system.
2. Describe the operating characteristics and parts of the three most common tape reeling systems.
3. Describe the physical characteristics of the two basic tape reeling configurations, *co-planar* and *co-axial*.
4. Describe the characteristics of *open-loop drive* and *closed-loop drive* tape transport configurations and the three most common *closed-loop* designs.
5. Describe the capstan speed control function of a tape transport system and the relationship of the six basic parts of a typical capstan speed control unit.
6. Explain why, and describe how, magnetic tape transports must be cleaned and degaussed.

INTRODUCTION

Magnetic tape recorder transports are precisely built assemblies that move the magnetic tape across the magnetic heads and hold and protect the tape. Figure 4-1 shows a basic tape transport assembly. Tape transports have four basic parts:

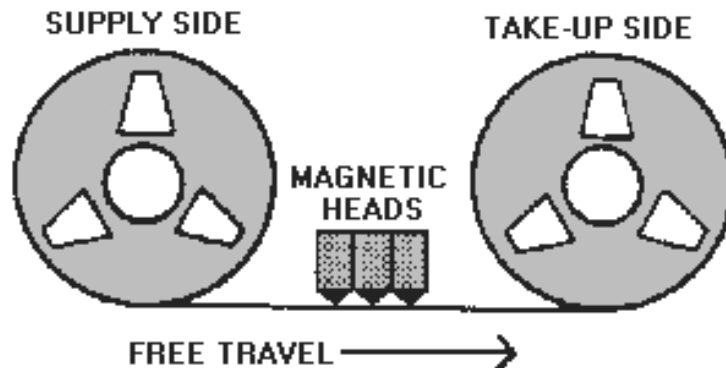


Figure 4-1.—Basic tape transport assembly.

1. A **tape reeling system** that, with the aid of tape guides, physically moves the tape across the magnetic heads.
2. A **tape speed control system** that monitors and controls the movement of the magnetic tape.
3. An **electronic subsystem** that activates the reeling device to move the magnetic tape.
4. A **basic enclosure** that holds and protects the reels or cartridges of magnetic tape.

This chapter describes these basic parts, tells how they work, and shows diagrams of the more common ones.

TAPE REELING SYSTEMS

A basic magnetic recorder tape reeling system (figure 4-1) has one supply reel and one take-up reel. Its job is to move the magnetic tape from one reel to the other. When this happens, four things occur:

1. The supply reel feeds out magnetic tape at a constant tension.
2. The tape passes the magnetic heads in a straight line.
3. The take-up reel accepts the magnetic tape at a constant tension.
4. Both the supply and take-up reels start and stop smoothly while maintaining the proper tape tension.

These four things must happen, or the magnetic tape could be damaged. Three of the most commonly used tape reeling systems are (1) take-up control, (2) two-motor reeling, and (3) tape buffering.

TAKE-UP CONTROL REELING SYSTEMS

This system uses a motorized take-up reel which pulls the magnetic tape off of a *free-spooling* supply reel. It maintains tape tension by using mechanical drag on the supply reel. As you might guess, this method has its disadvantages. It only works in one direction, and the tape tension doesn't remain constant throughout the reel. As the supply reel gives out tape, the tape tension varies. Uneven tape tension can cause stretched tape, poorly wound tape reels, and tape damage during starts and stops.

TWO-MOTOR REELING SYSTEMS

To overcome the problems of take-up control reeling systems, designers added a motor to the supply reel. By using two motors, the magnetic tape direction can be forward or reverse.

Two-motor reeling configurations usually use dc (direct current) motors, instead of ac (alternating current) motors, because dc motors run smoother and are easier to control. To help control tape tension, a small hold-back voltage is added to the motor for the supply reel.

Unfortunately, two-motor reeling systems do not properly control tape tension during starts and stops. Something called *tape buffering* must be added.

TAPE BUFFERING REELING SYSTEMS

Controlling a recorder's tape tension during starts and stops is a big problem. Tape buffering overcomes this problem by regulating the tape reel speed and by protecting against changes in tape tension.

Every manufacturer of high-quality, high performance magnetic tape recorders uses some sort of tape buffering. It's especially important in magnetic recorders that operate at many different speeds, where precise tape tension must be maintained.

Figure 4-2 shows the relationship between the tape reeling system and the tape buffering system. As you can see, the speed at which a tape reel will give up or take up magnetic tape is controlled by its respective speed control servo. Feedback from the supply and take-up buffers tells the servo to speed up or slow down.

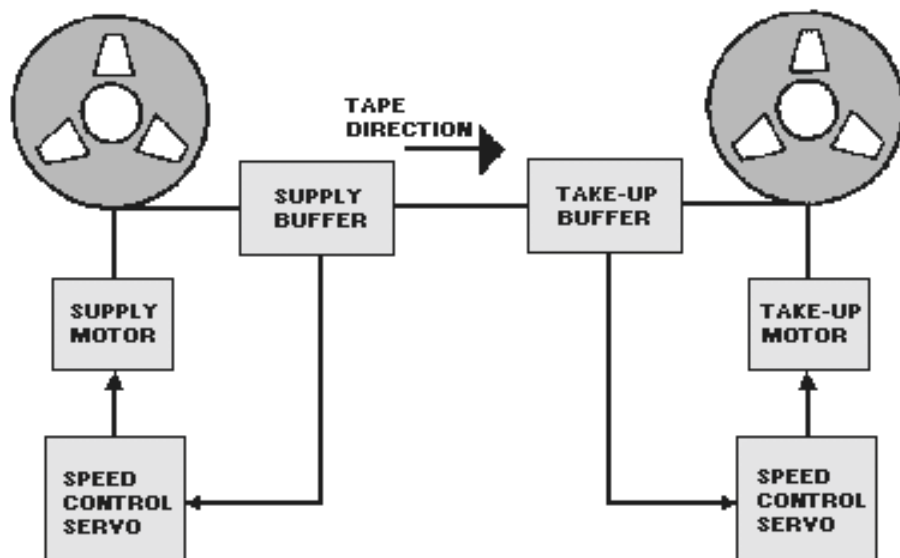


Figure 4-2.—Tape buffering arrangement.

There are two basic types of reeling system buffers: (1) spring-tension, and (2) vacuum-column.

1. **Spring-tension** buffering systems use an electro-mechanical device to sense changes in tape tension. These changes are *feedback* that the speed control servo needs to adjust the speed of the tape reels. Figures 4-3 and 4-4 show two of the more common arrangements for spring-tension buffers.

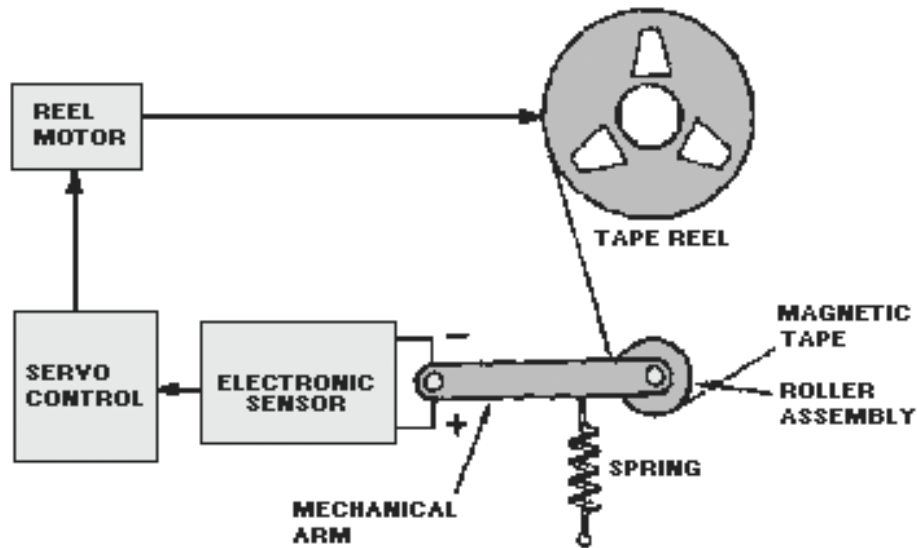


Figure 4-3.—Mechanical arm spring-tension tape buffering.

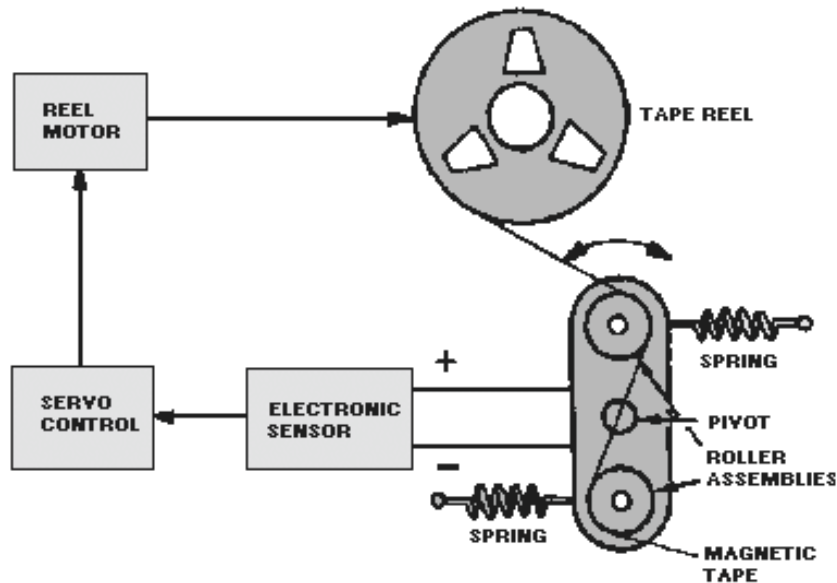


Figure 4-4.—Mechanical arm spring-tension tape buffering.

2. **Vacuum-column** buffering systems operate like the spring-tension systems. They also regulate the speed control servos that control tape reel speed. But, as shown in figure 4-5, the vacuum-column buffer system uses a vacuum chamber instead of a spring to hold a length of magnetic tape as *slack* during tape recorder starts and stops. An electronic sensor in the vacuum chamber helps to control how much tape is in the buffer.

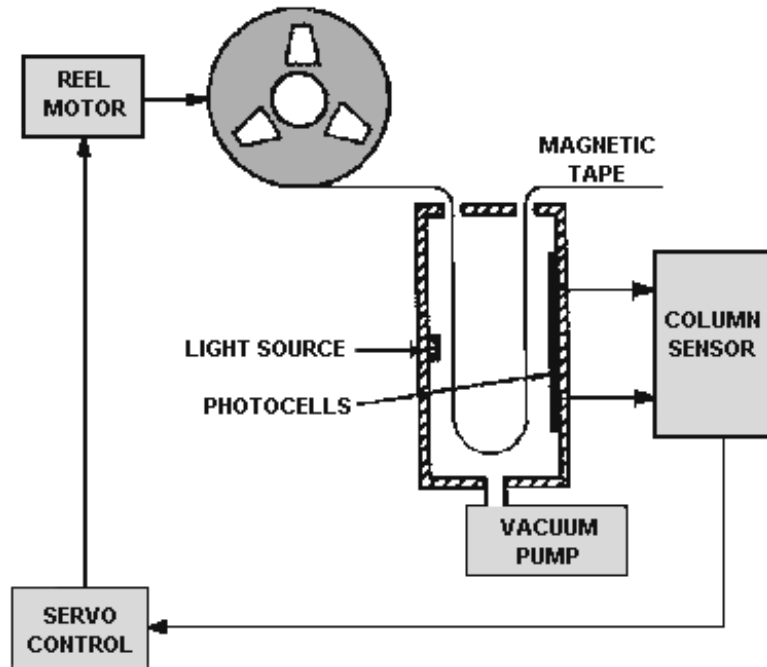


Figure 4-5.—Vacuum-column tape buffering system.

TAPE GUIDES

Another job of a tape reeling system is to make sure the magnetic tape is protected from damage during operation. To do this, tape reeling systems use tape guides. Tape guides come in two designs, *fixed* and *rotary*. Both of these are shown in figure 4-6. Each type of tape guide has its drawbacks. Fixed tape guides produce a lot more friction, and rotary tape guides are more likely to cause errors because of their moving parts.

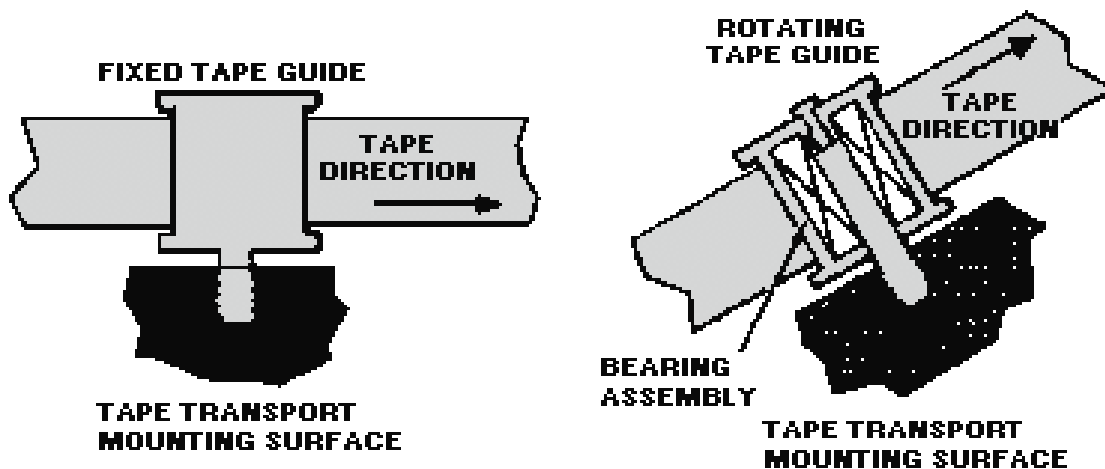


Figure 4-6.—Typical fixed and rotary tape guides.

Tape guides are strategically placed in a tape reeling system to make sure the magnetic tape is kept straight with respect to the supply and take-up reels and the magnetic heads. Some magnetic recorders use only fixed tape guides, some use rotary tape guides, and some use a combination of the two.

TAPE REELING CONFIGURATIONS

There are two basic tape reeling configurations: (1) co-planar, and (2) co-axial. Both of these describe the physical relationship between the supply reel and the take-up reel. The co-planar, which is used more often than the co-axial, has the supply reel and the take-up reel side by side. Figure 4-7 shows this configuration.

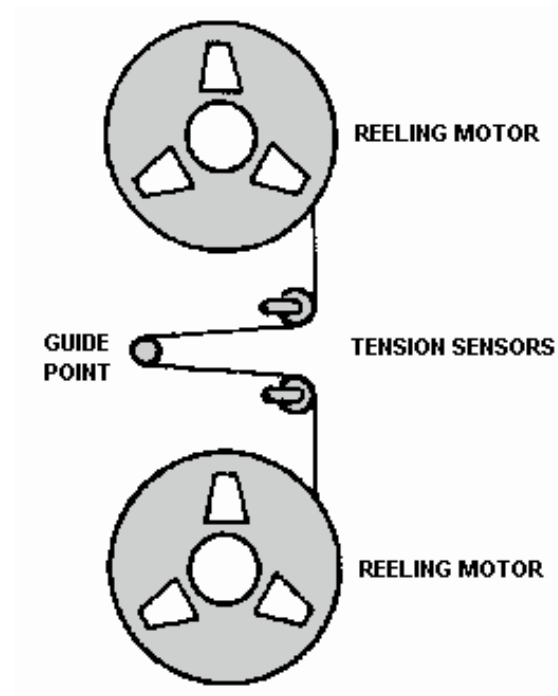


Figure 4-7.—Co-planar tape reeling configuration.

The co-axial configuration is used when physical space is limited. It places the supply and take-up reels on top of each other. Figure 4-8 shows this configuration.

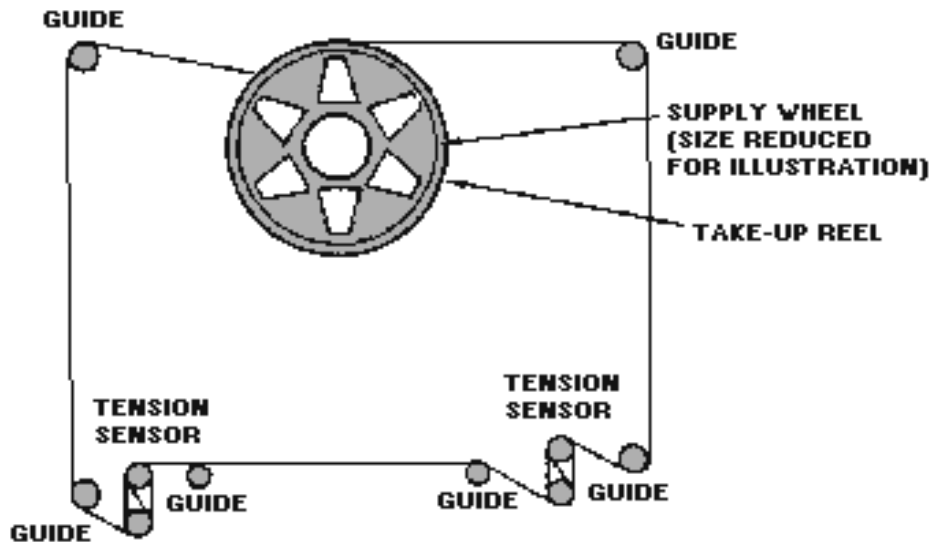


Figure 4-8.—Co-axial tape reeling configuration.

- Q-1. What are the four basic parts of a magnetic tape recorder's tape transport system?
- Q-2. What are the three most commonly used tape reeling systems?
- Q-3. What are two disadvantages of the take-up control reeling system?
- Q-4. What are two advantages of a two-motor reeling system over a take-up control reeling system?
- Q-5. What type of reeling system best controls a tape recorder's tape tension during starts and stops?
- Q-6. What are the two basic types of tape buffering reeling systems?
- Q-7. How do the tape guides on a tape reeling system protect the tape from damage during operation?

TAPE TRANSPORT CONFIGURATIONS

There are two types of tape transport configurations: (1) *open-loop capstan drive*, and (2) *closed-loop capstan drive*. The following paragraphs describe each of these.

OPEN-LOOP CAPSTAN DRIVE

This is probably the simplest tape transport configuration. Figure 4-9 shows how the magnetic tape is pulled off of the supply reel, taken across the magnetic heads, and wound onto the take-up reel. The tape is *pulled* by sandwiching it between a single capstan and a pinch roller. As the capstan turns, the friction between it and the pinch roller pulls the tape across the magnetic heads. The magnetic tape is held against the magnetic heads by using tape guides.

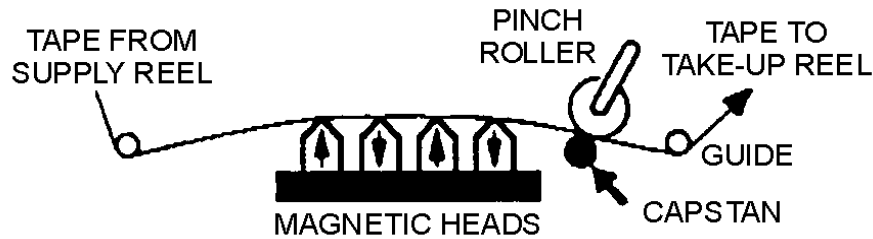


Figure 4-9.—Open-loop capstan drive tape transport.

The open-loop drive transport configuration has two major drawbacks:

1. It can only work in one direction. It can *pull* the tape, but it can't *push* it across the magnetic heads.
2. Tape tension and head-to-tape contact can vary. If the capstan motor hesitates or speeds up, the tape tension will vary.

CLOSED-LOOP CAPSTAN DRIVE

Closed-loop capstan drive tape transports were designed to overcome the drawbacks of the open-loop drive design. They use more than one capstan and/or pinch roller to *clamp* the magnetic tape in the area around the magnetic heads. This keeps tape tension constant and improves the quality of the recording or the playback. Figure 4-10 shows the basic arrangement of the closed-loop capstan drive.

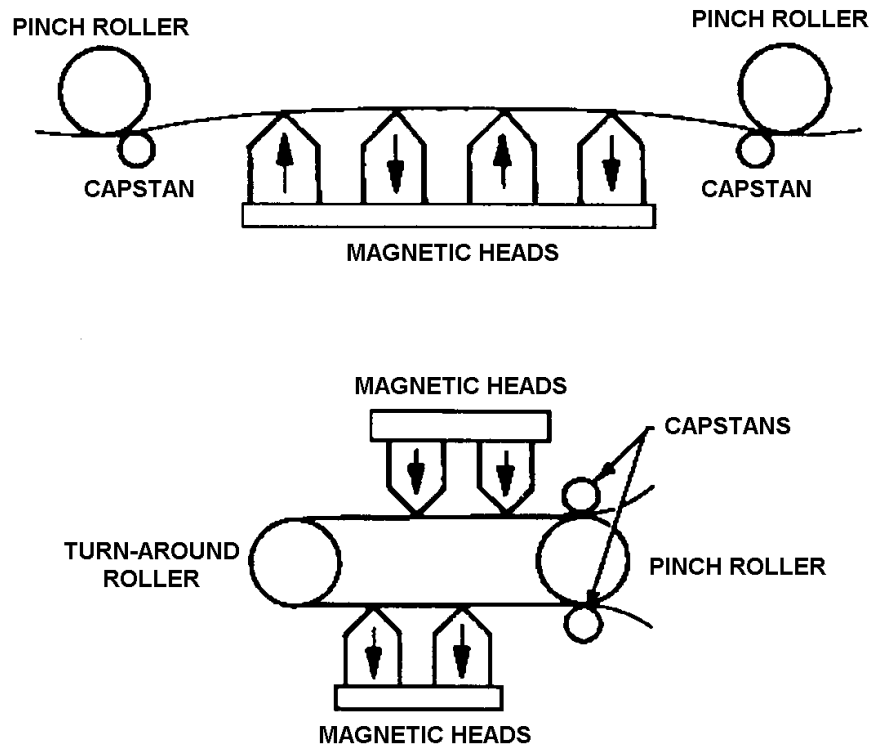


Figure 4-10.—Closed loop capstan drive tape transport.

The three most common closed-loop capstan drive designs are (1) *differential velocity capstans*, (2) *dual-motors dual capstans*, and (3) *peripheral drive capstans*.

Differential Velocity Capstans

Figure 4-11 shows a differential velocity capstan. In this design, the take-up capstan is made a little larger than the supply capstan. This causes the take-up capstan to pull the tape away from the heads slightly faster than the supply capstan feeds the tape to the heads. The result is a constant tape tension in the area around the magnetic heads.

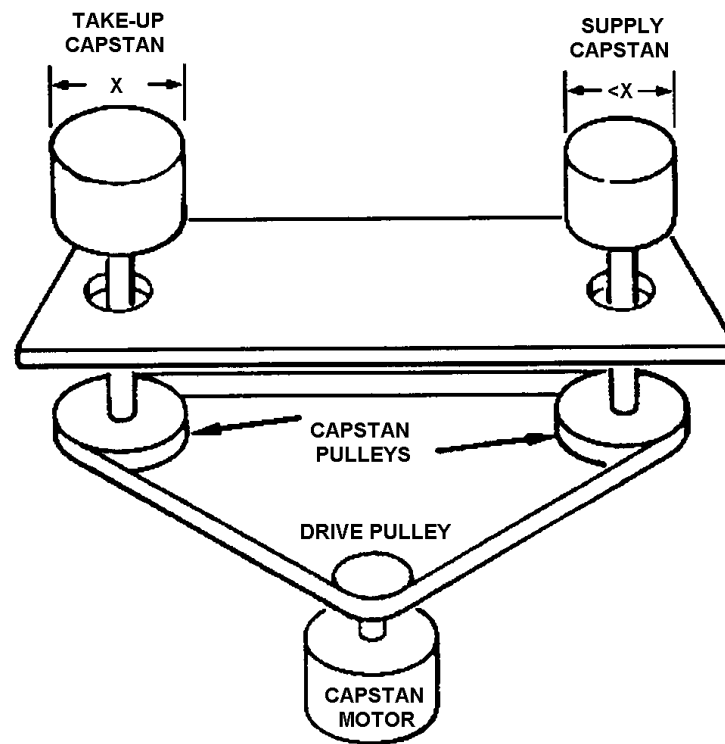


Figure 4-11.—Differential velocity capstan drive.

Both capstans are turned by a single motor which is coupled to the capstan pulleys by a belt. This arrangement is very efficient in one direction, but, unfortunately, differential velocity capstans don't work in reverse. If you reversed the tape direction, a negative tension would occur, and the tape would bunch up in the area around the magnetic heads.

Dual-Motors Dual Capstans

Figure 4-12 shows a dual-motor dual capstan drive. In this design, each capstan is driven by its own motor. Tape tension is maintained by slowing down one of the motors. When reverse tape motion is needed, the opposite motor is slowed down.

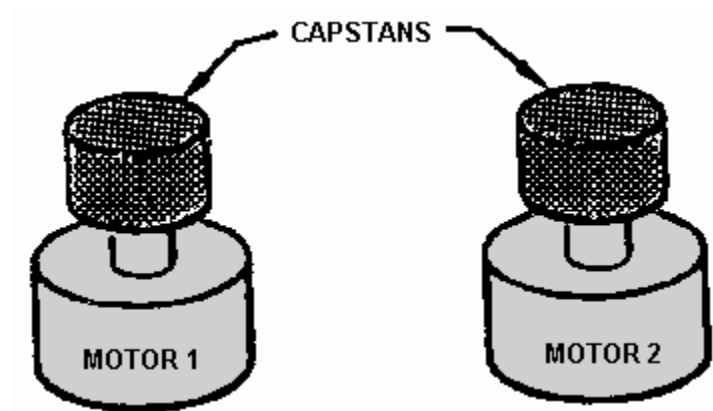


Figure 4-12.—Dual-motors dual capstans drive system.

Peripheral Drive Capstans

In this design, the magnetic tape is moved by a capstan placed directly against the tape reel or tape pack. Figure 4-13 shows two different peripheral drive capstan arrangements.

The first arrangement, figure 4-13A, shows a single capstan design. In this method, two tightly wound tape reels, without flanges, are pushed against the capstan. As the capstan turns, it forces the tape reels to turn in the appropriate direction. Magnetic tape tension is maintained by using either spring loading or servo control.

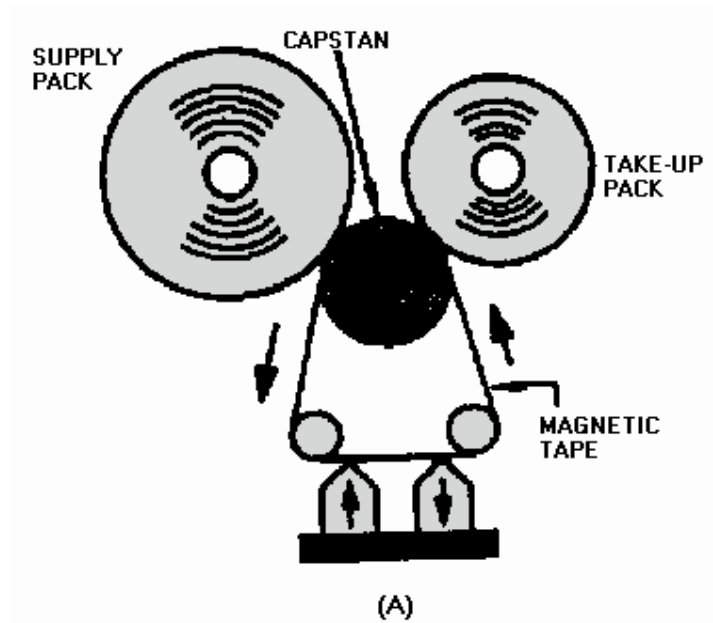


Figure 4-13A.—Peripheral drive capstans.

The second arrangement, figure 4-13B, uses two capstans. In this method, the two tightly wound tape reels, without flanges, are pressed directly against the capstans. Tension in the magnetic head area is maintained by controlling the speed of the individual capstans.

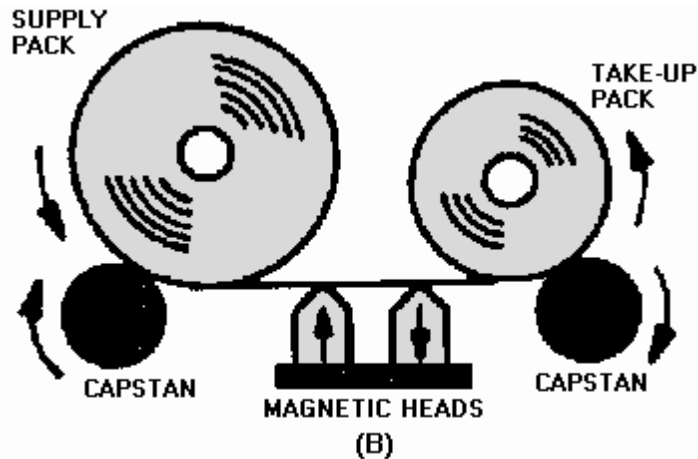


Figure 4-13B.—Peripheral drive capstans.

CAPSTAN SPEED CONTROL

Capstan speed control is an important part of the magnetic tape transport system. It makes sure the capstan is turning (1) at the right speed and (2) at a constant speed. This is important because errors in speed control can cause poor recordings and playbacks.

Capstans are turned either by a motor only, or by a motor, belt, and pulley arrangement. In either case, it's the motor that the capstan speed control function acts upon to do its job. A capstan speed control function typically consists of six basic parts. Figure 4-14 shows these six parts and how they're related. Each of the parts is described below.

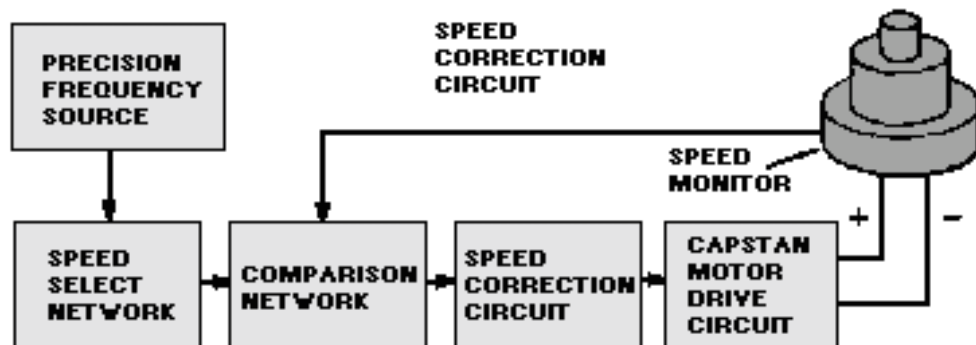


Figure 4-14.—Six parts of the capstan speed control function.

PRECISION FREQUENCY SOURCE

This part of the capstan speed control provides a reference frequency that the *speed select network* and the *comparison network* use to drive the capstan motor. The precision frequency source is usually a very-high-frequency crystal with an accuracy of at least .001 percent.

SPEED SELECT NETWORK

This network selects the desired operating tape speed. It takes the reference frequency from the *precision frequency source* and (depending on the desired operating tape speed) generates another specific reference signal that the *comparison network* uses to control the speed of the capstan. Table 4-1 is a list of the speed control reference signal frequencies for the various operating tape speeds.

Table 4-1.—Typical speed control reference signal frequencies

<u>Operating Tape Speed</u> (inches per second)	<u>Speed Control Frequency</u> (kilohertz)
15/16	1.5625
1 7/8	3.125
3 3/4	6.25
7 1/2	12.5
15	25
30	50
60	100
120	200
240	400

CAPSTAN SPEED MONITOR

This circuit monitors the true capstan motor speed. It sends the true speed to the *comparison network* circuit. Most capstan speed monitor circuits are made using a photo-optical tachometer that's directly attached to the shaft of the capstan motor. Figure 4-15 shows this.

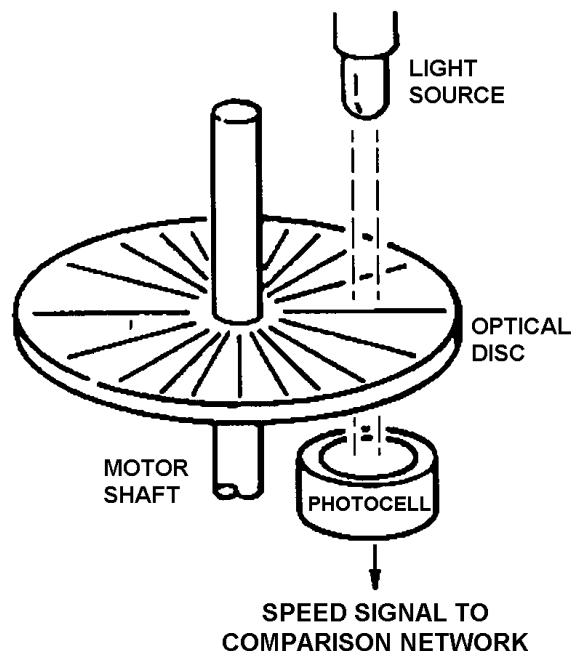


Figure 4-15.—Capstan speed monitor using a photo-optical tachometer.

COMPARISON NETWORK

This network takes the input signals from the *speed select network* and the *capstan speed monitor*, compares the two signals, and decides if the capstan is at the right speed. If not, it tells the *speed correction circuit*.

Sometimes, a third input signal, which comes from the magnetic tape itself, is supplied to the *comparison network*. It's called a *servo control from tape signal*. Tape recordings made on a specific recorder are sometimes shipped off for further analysis and played back on a different recorder. To help compensate for speed errors in the tape transport systems of the two recorders, the *precision reference frequency* of the originating recorder is recorded onto a track of the magnetic tape. During playback, this reference signal is also fed to the recorder's *comparison network* and is used to correct speed errors.

SPEED CORRECTION CIRCUIT

This circuit takes speed correction signals from the *comparison network* and tells the *capstan motor drive circuit* to either speed up or slow down the capstan motor.

CAPSTAN MOTOR DRIVE CIRCUIT

This circuit takes the speed-up or slow-down signals from the speed correction circuit and actually speeds up or slows down the capstan motor.

MAGNETIC TAPE TRANSPORT MAINTENANCE

If you want good recordings and playbacks, you must keep magnetic tape transports clean and demagnetized. The following paragraphs describe preventive maintenance procedures for magnetic tape transport systems.

MAGNETIC TAPE TRANSPORT CLEANING

You can clean most magnetic tape transports with isopropyl alcohol, cotton swabs, and lint-free cloths. (Caution: Cotton swabs are not lint free, so use them only in places you can't get to with the lint-free cloths.) Figure 4-16 shows a technician cleaning a capstan. Here are some other points to remember:

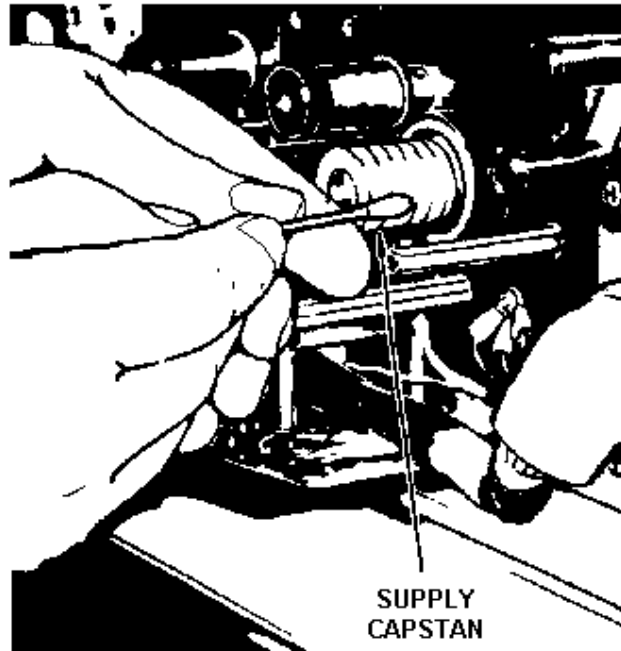


Figure 4-16.—Cleaning the capstan on a magnetic tape transport system.

- DO always remove the magnetic tape from the transport before cleaning it.
- DO apply the cleaner onto the lint free cloth or cotton swab; DON'T apply it directly onto the tape transport.
- DO pay extra attention to the flanged parts of tape guides. It's here that oxide particles collect the most.
- DON'T use the same lint-free cloth or cotton swab to clean many parts of the tape transport. Switch cloths and swabs often. If you don't, you may transfer dirt and oxide particles from one part of the tape transport to another.

MAGNETIC TAPE TRANSPORT DEMAGNETIZING

With use, tape transport parts become magnetized. It's hard to say *exactly* what will happen if the magnetic tape passes a magnetized part of the tape transport before the tape is recorded on. The effects can range from just a little more noise on the tape to a complete tape saturation. Either way, magnetized tape transport parts can ruin magnetic recordings.

To prevent this, you must periodically demagnetize the tape transport. The procedures for doing this are identical to those listed in chapter 2 for demagnetizing magnetic heads. You'll even use the same manual hand-held degausser you saw in figure 2-8 of chapter 2. Figure 4-17 shows a technician demagnetizing a tape guide.

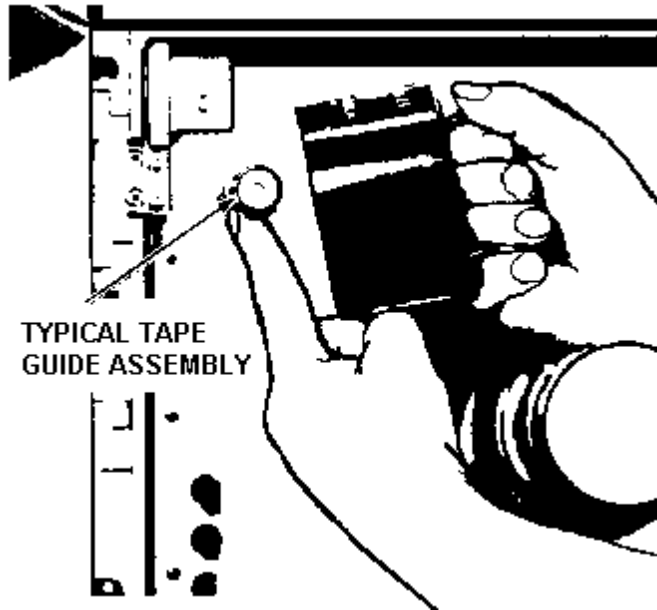


Figure 4-17.—Demagnetizing a tape guide with a hand-held degausser.

- Q-8. There are two types of tape transport configurations, open-loop capstan drive and closed-loop capstan drive. What are two major disadvantages of open-loop capstan drive tape transports?*
- Q-9. How do closed-loop capstan drive tape transports overcome the disadvantages of the open-loop drive design?*
- Q-10. What are the three most common closed-loop capstan drive designs?*
- Q-11. How do tape transports with differential velocity capstans maintain a constant tape tension in the area around the magnetic heads?*
- Q-12. How do dual-motor dual capstan drives maintain a constant tape tension while operating in either a forward or reverse direction?*
- Q-13. What are the two critical functions of the capstan speed control part of a magnetic tape transport system?*
- Q-14. Which part of the capstan speed control function monitors the true capstan motor speed?*
- Q-15. Sometimes it's necessary, but why should you avoid using cotton swabs when cleaning a magnetic tape transport?*
- Q-16. When cleaning the parts of a tape transport, why should you switch lint-free cloths and swabs often?*
- Q-17. What equipment should you use to de-magnetize a magnetic tape transport?*

SUMMARY

Now that you've finished chapter 4, you should be able to describe magnetic tape transport systems in terms of their operating characteristics, parts, and preventive maintenance requirements. The following is a summary of the important points in this chapter.

A **MAGNETIC TAPE RECORDER TRANSPORT** has four basic parts: (1) tape reeling system, (2) tape speed control system, (3) electronic subsystem, and (4) basic enclosure.

The **TAPE REELING SYSTEM** must move the tape in a straight line at a constant tension, and it must start and stop smoothly while maintaining the proper tension.

Three of the **MOST COMMON REELING SYSTEMS** are (1) take-up control, (2) two-motor reeling, and (3) tape buffering.

The two types of **TAPE TRANSPORT CONFIGURATIONS** are (1) *open-loop capstan drive* and (2) *closed-loop capstan drive*. The open-loop type works in only one direction, and the tape tension can vary. The closed-loop type keeps the tape tension constant.

Three types of **CLOSED-LOOP CAPSTAN DRIVES** are (1) differential velocity capstans, (2) dual-motors dual capstans, and (3) peripheral drive capstans.

The **CAPSTAN SPEED CONTROL** component of a tape transport keeps the capstan turning at the correct operating speed and at a constant speed. It has these six parts: (1) precision frequency source, (2) speed select network, (3) capstan speed motor, (4) comparison network, (5) speed correction circuit, and (6) capstan motor drive circuit.

You should **CLEAN** magnetic tape transports with isopropyl alcohol, cotton swabs, and lint free cloths and **DEMAGNETIZE** them using a hand-held degausser.

ANSWERS TO QUESTIONS Q1. THROUGH Q17.

A1.

- a. *Tape reeling system.*
- b. *Tape speed control system.*
- c. *Electronic subsystem.*
- d. *Basic enclosure.*

A2.

- a. *Take-up control.*
- b. *Two-motor reeling.*
- c. *Tape buffering.*

- A3.
- a. *It only works in one direction.*
 - b. *The tape tension varies as the supply reel unwinds, which can cause damage during starts and stops.*
- A4. *The two-motor configuration runs in both directions and a holdback voltage helps control tape tension, but it does not properly control tape tension during starts and stops.*
- A5. *A tape buffering reeling system.*
- A6.
- a. *Spring-tension **buffering systems**.*
 - b. *Vacuum-column **buffering systems**.*
- A7. *They keep the tape straight with respect to both the supply and take-up reels and the magnetic heads.*
- A8.
- a. *Only operates in one direction.*
 - b. *The tape tension and head-to-tape contact can vary.*
- A9. *Closed loop capstan drive transports use more than one capstan to clamp the tape in the area around the magnetic head.*
- A10.
- a. *Differential velocity capstans.*
 - b. *Dual motors dual capstans.*
 - c. *Peripheral drive capstans.*
- A11. *The supply capstan is slightly larger than the take-up capstan. This causes the take-up capstan to pull the tape slightly faster than the supply capstan feeds the tape.*
- A12. *Each capstan is driven by its own motor. It maintains tape tension by slowing down one of the motors. When the tape motion is reversed, the opposite motor is slowed down.*
- A13. *Makes sure the capstan turns at the right speed and at a constant speed.*
- A14. *Capstan speed monitor.*
- A15. *Cotton swabs are not lint free.*
- A16. *You may transfer dirt or oxide particles from one part of the tape transport to another.*
- A17. *A hand-held degausser.*

